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THE GEOLOGY OF THE STRATHBOGIE IGNEOUS COMPLEX, VICTORIA

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Abstract

The members of the Strathbogie Igneous Complex are described and petrologically linked with other Upper Devonian igneous rocks in Victoria. In quartz-biotite-hypersthene dacite, garnet, hypersthene and cordierite have crystallized from a contaminated magma. Fluctuations in environmental factors have produced a second generation of cordierite and hypersthene which form poly-coronas and dactylites after pyrogenetic garnet. Anthophyllite pseudomorphs after hypersthene reflect the degree of assimilation in the basaltic magma. The dacite has metamorphosed a granodiorite porphyrite apparently related to the same period of igneous activity. The contact zone between the Violet Town Volcanics and the Strathbogie Granite represents an annular fracture along which large sedimentary blocks have subsided. This suggests the mechanism of emplacement of the Strathbogie Igneous Complex. Widespread aplites intruded along the fracture contact zone have metasomatized a granitic intrusion.

Introduction

The Strathbogie Igneous Complex consists of the Violet Town Volcanics and the Strathbogie Granite which, with the Terip Terip and Trawool Granites, forms a conspicuous mass in central Victoria. The complex occupies the western half of the County of Delatite and a small portion of the northern part of the County of Anglesey. The Hume Highway skirts its western edge and the Mansfield-Benalla road coincides with the eastern boundary. The Strathbogie Ranges with its highest peaks, Mt. Barrenhet, Mt. Separation and Mt. Wombat, form the high region (approximately 2,000 ft.) of the Strathbogie Granite province. Mr. Sugarloaf is a prominent landmark situated on the contact between the Violet Town Volcanics in the north and the Strathbogie Granite in the south.

Reconnaissance mapping was carried out by the author with the aid of aerial photographs, kindly supplied by the Mines Department of Victoria, detailed mapping being confined to the Violet Town Volcanics and its contact with the Strathbogie Granite.

Physiography

The Strathbogie Igneous Complex occupies the lowest elevated region of the north-western edge of the Eastern Highlands, and probably some of its summit levels represent relics of the Cretaceous Terrain prior to uplift and dissection. The mature undulating granite surface with a comparatively thick soil cover forms a contrast with the more dissected volcanic province. Differential erosion produces other contrasts in relief in the south, where the undulating granite country passes into the more dissected and symmetrical ridges of Silurian sediments. Physiography provides evidence for the emplacement of the Violet Town Volcanics as a scarp extends for about three miles at the foot of Mt. Sugarloaf parallel to the (fracture) contact zone between the volcanics and the Strathbogie Granite. The scarp was probably formed by movements associated with the emplacement

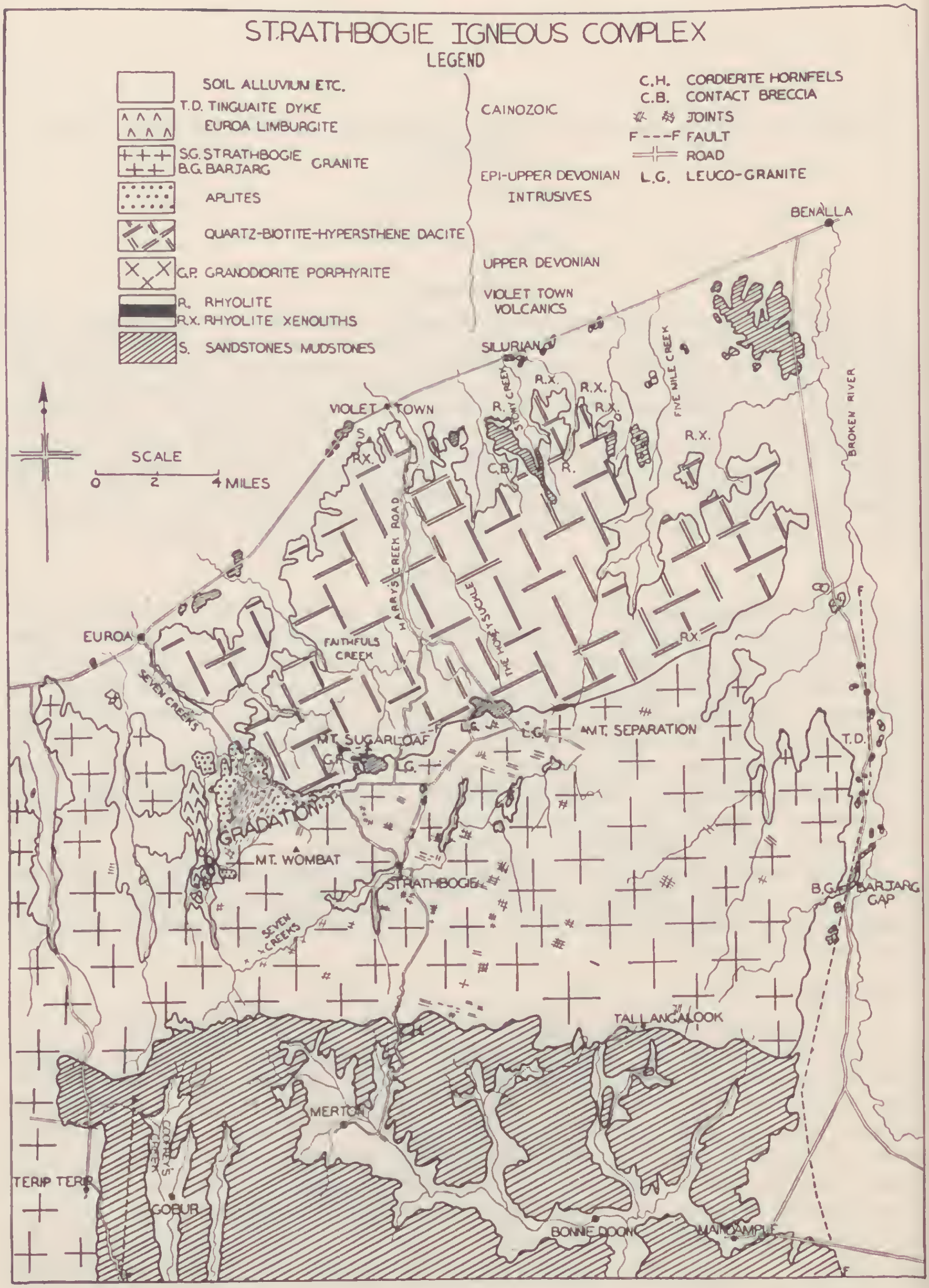

Fig. 1.—Geological Plan of the Strathbogie Igneous Complex.

of the volcanics. In this respect the large depression in the vicinity of Mt. Sugarloaf is also important.

The course of the main river, Seven Creeks, is influenced by the joint pattern in the Strathbogie Granite. The joints are vertical, widely spaced and trend N.N.E. and S.W., and in the late stage granitic intrusives they are closely spaced with a predominant N.N.E. trend. The joints in the volcanic province differ from those in the granite by their lack of orientation, closer spacing and in their association with horizontal joints. The variation in joint pattern and textural features in the two provinces is reflected in their present state of dissection.

The eastern boundary of the Terip Terip Granite is flanked by a prominent north-south scarp, which is produced by a fault parallel to the granite-sediment contact in the adjacent Silurian sediments.

The Barjarg Gap is an important physiographical feature separating the Tolmie Highlands in the east from the Strathbogie Ranges in the west and it provides a passage for the Broken River and the Benalla-Mansfield road. The Barjarg Gap has been linked with the formation of the disharmonious course of the Goulburn River, which was postulated by Fenner (1914) as the result of Tertiary block-faulting. Fenner's hypothesis was doubted by Hills (1932) who found evidence in support of differential erosion as the main structural control. The important points concerning the genesis of the Barjarg Gap are:

(i) The anomaly that exists between the gorge dissected in the granite ridge and the present Broken River.

(ii) The post-Strathbogie Granite fault which passes through the gap.

(iii) The resistant nature of the granite, which forms a small ridge in the gap (Summers, 1908).

(iv) The extensive alluvium deposits on the southern side of the gap extending towards the tributaries of the Goulburn River.

If the Strathbogie Ranges and the Tolmie Highlands were continuous in Upper Devonian times (Summers, 1908), the Barjarg Gap may have been the result of movements connected with the fault. However, from structural and petrological evidence it is doubtful whether the two provinces were continuous, and if this was the case the gap marks an important geological break (geocol) between two Upper Devonian Igneous Complexes. From its relationships with the Strathbogie Granite and a tinguaite dyke, the fault in the gap must be a late Palaeozoic or early Mesozoic event, and it is inconceivable that it had little or no effect on the formation of the Goulburn River system of which the Broken River is thought to have been a member.

The present gorge of the Broken River through the granite ridge, and the alluvium deposits, are evidence in support of Fenner's hypothesis (1914) that the original course of the Goulburn was through the Barjarg Gap.

Previous Work

Gregory (1903) postulated that the position of the pre-Older Basaltic divide was in the Strathbogie Ranges, an assumption which was later criticised by Hills (1934).

Summers (1908, 1914, 1923) established that a broad area of aplite separated a northern volcanic province, consisting of a "quartz-porphyrite" (now recognized as a quartz-biotite-hypersthene dacite) and an "adamellite-porphyry" (the recrystallized dacite), from an "adamellite" (granite) in the south. Owing to the coarse nature of the quartz-porphyrite, Summers suggested that the northern Strathbogie rocks were entirely intrusive in character, and also he attributed the negligible metamorphism of the volcanics to the low temperature of the aplite intrusion.

Despite the fact that the Strathbogie Igneous Complex has been linked with other well-known Upper Devonian granodiorite-dacite provinces by previous Victorian authors, David (1950) considered it to be a late Middle Devonian intrusive.

Mr. G. Ampt's chemical analysis of the Violet Town "hypersthene quartz porphyrite" is quoted in Summers (1914). Edwards (1936) has analysed the garnet (almandine) of the dacite.

General Geology

Silurian Rocks

The Strathbogie Igneous Complex was emplaced through a bedrock of alternating fine-grained sandstones and mudstones, which are green when fresh and weather brown owing to the oxidation of iron to limonite. A few plant remains were found in a road cutting at the 103 mile peg on the Hume Highway between Euroa and Violet Town, but the age of the rocks is regarded as Silurian on the lithological similarity with other Victorian Silurian sediments. They have a general northerly strike.

Similar sediments are found as small inliers (screens) and pebbles between the volcanic and granitic provinces, where they serve as contact indicators where the contact is not apparent. The fine-grained sandstones in these inliers exhibit cross-bedding and contain water-worn pebbles up to $\frac{3}{4}$ inch in size, which weather out forming small depressions upon the surface. Owing to their rubbly nature the attitude of the sedimentary inliers could not be determined.

The Silurian bedrock is severely brecciated in places, and where the succeeding igneous material has broken through the bedrock, sediments are incorporated in a contact breccia.

The sediments have been contact metamorphosed to a black flinty hornfels. Tourmaline has been introduced by pneumatolysis forming segregations in the least metamorphosed sediments. Generally the volcanic side of the sedimentary inliers is marked by a dark hornfels band and the granite side is practically unmetamorphosed due to the low temperature of intrusion of the granite and to pre-existing structures in the bedrock which have influenced the intrusion of the Strathbogie Granite and late stage intrusives.

The Upper Devonian Rocks

These rocks constitute the Violet Town Volcanics, which are restricted to the north of the complex and represented as "Dacites" on the Geological Map of Victoria (1936). It is important to note that the "Dacite" area includes the hills east and north-east of Euroa and the hillock to the east of Five Miles Creek in the Warrenbayne Parish, both of which are shown as "Granitic Rocks" on the 1936 Geological Map. The Violet Town Volcanics consist of the following members:

(1) Rhyolite.
(2) Granodiorite porphyrite.
(3) Quartz-biotite-hypersthene dacite.

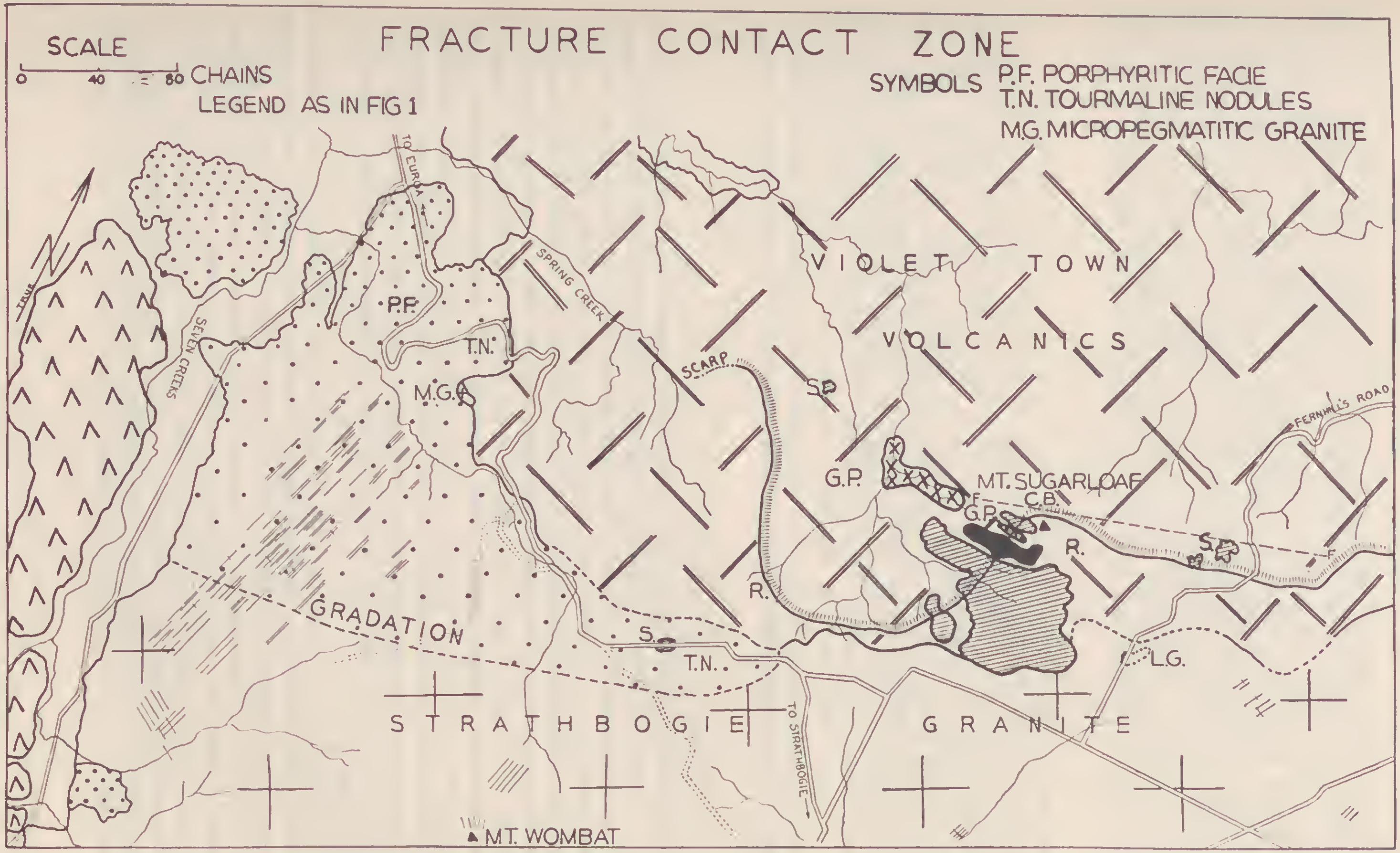

Fig. 2.—Detailed map of the western half of the fracture contact zone between the Violet Town Volcanics and the Strathbogie Granite.

Rhyolite

Volcanic activity began with the extrusion of a thin rhyolite flow on to an uneven bedrock surface. The basal rhyolite crops out with a low southerly dip in restricted areas along the northern edge of the volcanic province (Boho and Warrenbayne Parishes), where it is represented by xenoliths in the base of the dacite and in a contact breccia. Rhyolite xenoliths are rare along the western and eastern edges of the province, but they are conspicuous in the recrystallized dacite and the Mt. Sugarloaf contact breccia along the contact zone with the granite and sedimentary inliers. The rhyolite dips steeply to the north and is sheared on the western slopes of Mt. Sugarloaf. Although rhyolite is restricted in occurrence, the modified forms of rhyolite are the most important structural indicators of all the members in the complex.

Granodiorite Porphyrite

This rock is not strictly volcanic but is included with the Volcanics on petrological grounds. A small area of it occurs at the base of Mt. Sugarloaf, where it has been metamorphosed by the overlying dacite. Faulting has dislodged a small section of the outcrop into an elevated position on the western slopes of Mt. Sugarloaf. The granodiorite porphyrite is widespread as coarse acid schlieren in the younger dacite, which suggests that both were emplaced through a common channel or fracture in the bedrock. The porphyrite contrasts with the dacite in that it lacks bedrock xenoliths. Sufficient evidence is not available to determine the age relationship between the granodiorite porphyrite and the rhyolite. The porphyrite preceded the dacite, but mineralogical evidence suggests that they were closely related.

Quartz-biotite-hypersthene Dacite

The dacite is approximately 1,500 ft. thick and extends over most of the volcanic province. Mineralogically it is the important member of the Violet Town Volcanics, since it provides evidence for the petrogenesis of the complex. Many textural and mineralogical variations are encountered in this widespread flow. The hypersthene content decreases from the top of the dacite, seen at Fernhills Road, and grades to the north, east and west into a lower altered variety without any hypersthene, and into more recrystallized and possibly metasomatized varieties to the south towards the granitic province. The altered variety of the dacite grades into its chilled base, which contains abundant hypersthene, garnet and cordierite. The variable and gradational properties of the dacite evidently led Summers (1913) to divide the province into a "quartz porphyrite" and an "adamellite porphyry", but mineralogical and field evidence suggests that they belong to a single rock unit.

The dacite at its base contains many bedrock xenoliths and in the vicinity of Stony Creek it has brought the underlying rhyolite as xenoliths to the surface. It contains rare aplitic apophyses near the granite contact and exhibits evidence of metamorphism by increase in grain-size, biotite content and minor schistosity. Sedimentary xenoliths and acid schlieren increase in number towards the granite contact, especially on Mt. Sugarloaf, where they are accompanied by rhyolite xenoliths and terminate in hornfelsic and contact breccia types at several sedimentary inliers. The acid schlieren are numerous and elongated in the chilled base of the dacite.

The recrystallized characteristics are a feature of the dacite, and although recrystallization increases towards the granite, its widespread nature suggests that igneous activity other than the later granite was renewed after the formation of the dacite in the volcanic province.

The variable angle of dip of the contact of dacite with the sedimentary bedrock indicates that the dacite was both intrusive and extrusive. These characteristics together with the widespread occurrence of acid schlieren in the quartz-biotite-hypersthene dacite are very similar to those of the quartz-biotite-hypersthene dacite of the Black Spur area (Edwards, 1932). Similar schlieren are also characteristic of the quartz-biotite-hypersthene rhyodacite in the Cerberean Ranges (Thomas, 1947), and it is evident that the dacites are related to the same igneous activity.

The Epi-Devonian Rocks

These are intrusive, the main member being the Strathbogie Granite, which occupies the southern section of the complex. They comprise the main part of the petrographic province and are shown as "Granitic Rocks" on the Geological Map of Victoria, 1936. The eastern boundary of the Strathbogie Granite coincides with the 146° meridian and it extends west to Longwood, south towards Merton and south-west towards Seymour, where it grades into the Terip Terip Granite. In general it forms the highest part of the province (over 2,000 ft.) comprising the Strathbogie Ranges, Mt. Separation and Mt. Wombat. The intrusives can be classified as follows:

The Strathbogie Granite

The granite is the most widespread member of the Strathbogie Igneous Complex and exhibits three linear boundaries:

The eastern boundary coincides with a post-granite fault which passes through the Barjarg Gap. This fault is thought to be the northerly continuation of the Mansfield-Barkly fault (Thomas, 1947) and it has modified the trend of the Strathbogie Granite. The shattered granite is observed in a road cutting near the 18-mile road peg on the Benalla-Mansfield road, where two sets of shear planes are formed. The granite is intruded by a post-fault tinguaite dyke at this locality. Thomas (1947) has observed the Barjarg fault where carboniferous sediments are faulted against a band of fine-grained acid rocks, which are separated from the porphyritic cordierite Strathbogie granite by a narrow band of conglomerate. Contact metamorphism was not noticed along the eastern edge, over which there is a thick covering of Recent alluvium.

Along the southern boundary the metamorphic aureole is normally developed and different degrees of metamorphism exist. In general a narrow bend of high grade quartz-biotite-cordierite hornfels is in contact with the slightly chilled granite. This boundary was suggested by Fenner (1914) as the edge of a block fault and Thomas (1947) attributed the linear trend to pre-granitic faulting. Polished sections of the contact show the initial cross bedding of the sediments intact. The Silurian strike ridges are not disturbed in the vicinity of the granite and east-west faulting within a mile of the contact is absent. Moreover, lack of outcrops along this contact has probably assisted in its linear appearance on maps.

The eastern boundary of the Terip Terip Granite, which is continuous and identical with the Strathbogie Granite, is linear and the wall rocks consist of the usual narrow band of cordierite hornfels. A fault with a considerable throw strikes parallel to the contact in the Silurian sediments to the west of Godfrey's

Creek, and is represented by a scarp extending for three or four miles in a northerly direction. The youthful state of dissection of the scarp suggests a Tertiary age for the fault but the emplacement of the granite may have been influenced by northerly trending lines of weakness in the sedimentary bedrock.

The Strathbogie Granite grades into finer grained leuco-granites along the contact with the Violet Town Volcanics and possesses gradational or semi-intrusive relationships with late stage granitic intrusives. The leucocrates are generally separated from the dacite by sedimentary inliers or aplites and, in agreement with their gradational relationships with the granite, may be interpreted as a chilled border facies of the Strathbogie Granite. This is supported by the greater abundance of cordierite phenocrysts in the leucocrates similar to those in the main granite. Against this, however, sheared orthoclase phenocrysts in the granite over the gradational zone suggest a separate intrusion for the leucocrates, particularly the aplites. It is apparent from field and microscopical evidence that little time lapsed between the formation of the leucocrates and the intrusion of the aplites between the volcanic and granitic provinces.

Micro-pegmatic Granite

This occupies a restricted area along the contact between the wide aplite belt and the dacite, where metasomatism by later aplitic intrusives has produced a marked porphyritic texture in this granite. The granite grades into the Violet Town Dacite in the field, but from mineralogical evidence it has apparently been derived from the Strathbogie Granite and is tentatively listed here under the Epi-Devonian intrusives.

Late Stage Intrusives

These consist of biotite, tourmaline, cordierite and micro-pegmatitic aplites. They are concentrated along the granite-dacite contact and are exposed along the more eroded western part, where they form a large wedge-shaped zone, tapering along the contact towards Mt. Sugarloaf and Mt. Separation in the east and widening towards Euroa in the west. In general the belt occupies a wide depression separating the dacite and sedimentary inliers to the north at Mt. Sugarloaf and the granitic highlands at Mt. Wombat to the south.

Small biotite aplites also intrude the Strathbogie Granite as dykes, which are variable in strike when compared with the wider tourmaline-bearing aplites, in which quartz-tourmaline nodules are frequently formed. The tourmaline-bearing aplites conform to an east-west strike (i.e. parallel to the granite-dacite contact zone) and intrude the dacite; however, the aplites grade into the leuco-granites, which in turn possess gradational relationships with the granite.

The Barjarg Granite

This occupies the high ground at the junction of the Broken River and Sandy Creek in the Barjarg Gap. The granite is considered to be closely related to the Strathbogie Granite and it has been sheared by the fault which passes through the Barjarg Gap.

Metamorphic Rocks

Low grade hornfels occurs between the Violet Town Volcanics and the relatively unaltered sedimentary bedrock. The high grade flinty quartz-biotite-cordierite hornfels is exposed over a zone of variable width up to 15 feet along the southern

Strathbogie Granite and sedimentary contact. Members of the volcanic formation are in contact with the sedimentary inliers on Mt. Sugarloaf, where quartz-biotite hornfels is formed together with peculiar hybrid types and contact breccias, whose composition and texture depend upon the degree of admixture of sediment and volcanics as well as the amount of flow of the lavas. The contact breccia is also formed on the western ridge of Stony Creek, where the dacite has broken through the sedimentary bedrock and basal rhyolite, both of which form the main part of the breccia.

Cainozoic Rocks

Limburgite

This occurs as a flow situated about three miles south of Euroa, occupying a narrow strip approximately six miles long on the western banks of Seven Creeks. Hills (1938) correlated it with the younger members of the Newer Volcanic Series on physiographic evidence. The flow is approximately 30 feet thick and exhibits columnar jointing. Scoria, ash beds and volcanic cones associated with the limburgite have been mentioned by Dunn (1914).

Tinguaite (?)

This occurs as a dyke, exposed in an extremely weathered condition in a road cutting on the Mansfield-Benalla road near the 18 mile road peg. It intrudes the intensely sheared Strathbogie Granite along one of the shear planes. The dyke is post-granite and post-Barjarg faulting and it probably belongs to the dyke swarm of the Older Volcanics, which are so common in eastern Gippsland. Similar dykes have been recorded by Skeats in the Tolmie Ranges and he has correlated these and those of Tabberabbera and Omeo (1928) with Middle to Late Cainozoic alkali rocks of the Mt. Macedon and the Western Districts. Moreover, Skeats believes that they have been intruded along tension cracks associated with differential movements of the eastern Australian uplift, and from this aspect the association of the Barjarg tinguaite dyke with faulting is important.

Petrology

General Characteristics of the Petrographic Province

The consanguinuity of this comagmatic province is revealed in the mineralogical, textural and geological associations of each member of the suite. The characteristic feature of the volcanics is the presence throughout of coarse acid schlieren of granodiorite porphyrite, which are more elongated in the base than the upper parts of the quartz-biotite-hypersthene dacite. Xenoliths of sedimentary rock and rhyolite occur in the dacite, particularly at its base.

The acid affinities of the province are revealed by the predominance of quartz amongst the phenocrysts. Hypersthene, cordierite and garnet are always present in varying amounts, either alone in their corroded and altered forms or as a reaction trio in the garnet-cordierite-hypersthene coronas and the associated dactylites. The amount of hypersthene fluctuates between the upper and basal portions of the dacite and is at a minimum in the altered, metasomatized(?) and recrystallized varieties.

Approximately ninety per cent of the Strathbogie Complex consists of granite and dacite and most of the members are coarse-textured and porphyrite. Owing to these features the members of the volcanic province are difficult to visualize as belonging to the extrusive class of igneous rocks. The plagioclases are andesine and in excess of the potash felspars in the earlier rock types; however albite-oligoclase with potash felspar, sometimes microperthitic, are prominent in later differentiates. The potash content increases from the oldest to the youngest member in agreement with the variation in the felspar composition and potash is in excess in the granite and late stage intrusives. Tourmaline is prominent amongst the groundmass constituents and it is present in greater amounts in the aplites, where it is mainly represented by quartz-tourmaline nodules.

There is a tendency for igneous contacts to be gradational throughout the province. This is exemplified by the change from the chilled dacite base through an altered dacite form to the widespread recrystallized dacite, which in turn grades into a porphyritic metasomatized granite. The gradation across the strike in the intrusives is from fine-grained biotite aplites through porphyritic leuco-granite facies to the coarse porphyritic Strathbogie Granite. The granite-dacite contact is poorly defined but often along this contact sedimentary inliers forming an abrupt hornfels contact with the dacite grade, on the granite side, into the late stage granitic intrusions which flank the granite along this contact zone. Gradational characteristics are also present in the individual members of the complex.

Although metamorphism and metasomatism have produced important mineralogical changes in some members of the complex, their effects are limited and the schistose and gneissose structures present in other Victorian dacites are rarely observed in the dacite, owing to the influence of pre-existing structures upon the granite emplacement. The degree of metamorphism between the Strathbogie Granite and the sediments varies in the south probably owing to the variable composition of the wall rocks or removal of the products of reaction by convection.

Petrography

Rhyolite

Rhyolite either is recognized as a flow or as recrystallized and cataclastic xenoliths in the dacite. It is highly porphyritic, quartz up to 4 mm., terminated by rhomhohedra, being the most conspicuous feature. Veinlets of secondary quartz and tourmaline have been introduced into the groundmass, in which viriditic particles conform to a definite flow pattern. The accessory minerals comprise serpentine and other chloritic material after cordierite, garnet with poikiloblastic inclusions of magnetite and biotite, as well as biotite segregations after sedimentary inclusions. The texture of the rhyolite resembles a nevadite, but it differs from other Victorian Upper Devonian Nevadites by the absence of subordinate acid plagioclase phenocrysts.

In the recrystallized rhyolite xenoliths the groundmass changes from cryptocrystalline to microgranular, orthoclase tends to be microperthitic, and with the development of lacinear borders orthoclase and quartz increase in size, quartz embayments are destroyed and both quartz and orthoclase become anhedral. Original garnet possesses a sieve texture in the new environment and owing to reciprocal reaction between xenolith and host biotite increases in content. In general, with increase in recrystallization of the original rhyolite nevadite affinities are more apparent.

In thin section the cataclastic recrystallized rhyolite possesses a blastoporphyritic texture, in which quartz, in particular, and orthoclase phenocrysts are intensely sheared. Quartz and to a lesser extent orthoclase have been considerably elongated by the overriding of brecciated segments. Preferred shearing planes are recognized in the phenocrysts and despite its xenoblastic appearance the original embayed form of quartz is preserved. Biotite is flexible to the shearing force and tends to segregate into glomeroporphyritic clusters. However, if the prominent (001) cleavage of biotite coincides with the shear, shearing and gliding of cleavage segments occur along the cleavage planes. Cordierite is never preserved in the fresh state, and is altered to an aggregate of pinite and a bronze-coloured mineral with no cleavage, high refractive index and practically isotropic. Sedimentary xenoliths derived from the adjacent inliers are numerous.

It is apparent that there are several varieties of the basal rhyolite flow ranging from the original unaltered flow through various recrystallized and micro-mylonitic types, which depend on their structural setting in the Violet Town Volcanics. The recognition of all varieties of rhyolite is very important in the final interpretation of the structure of the volcanics.

Granodiorite Porphyrite

The granodiorite may enter the Tonalite class with chemical analysis, but it is tentatively listed as a granodiorite. As with rhyolite, different varieties of the granodiorite can be recognized according to its structural setting in the Violet Town Volcanics.

Micro-granophyric Granodiorite Porphyrite. Doubly-terminated quartz crystals up to 7 mm., oscillatory zoned plagioclase (Ab_{62}), biotite and pinitized cordierite phenocrysts are set in a micro-granophyric groundmass. The plagioclase phenocrysts tend to form haphazardly on to each other, emphasizing their size up to 4 mm. Biotite is usually chloritized. Preferred pinitization directions in cordierite parallel cleavage and twin planes and the usual green pinite product is accompanied by a yellow to colourless isotropic alteration. Accessories are zircon, enclosed in biotite, apatite, magnetite and muscovite. The groundmass is the characteristic and distinguishing property of this rock. All varieties of quartz and orthoclase intergrowths are present, ranging from micro-pegmatite through micro-spherulitic to cryptographic associations. Subordinate micro-phenocrysts of plagioclase are also present in the groundmass.

Dark clots associated with biotite are also another feature of the granodiorite porphyrite. The centres of these segregations consist either of anthophyllite pseudomorphs after hypersthene, or cummingtonite and quartz. The anthophyllite pseudomorphs contain apatite and the magnetite inclusions of the original hypersthene. The anthophyllite fibres are generally replaced by biotite. Occasionally antigorite pseudomorphs the pyroxene. The cummingtonite is in small plates or sheaves of needles associated with quartz, biotite, magnetite and pyrrhotite. These minerals are surrounded by an inner brown biotite rim, which grades out into an outer dark green biotite in contact with the groundmass. The change in colour of biotite may be the initial stages in the deuteric alteration to chlorite. The mineralogy of the granodiorite porphyrite suggests that it is closely related to the quartz-biotite-hypersthene dacite.

Cataclastic and Recrystallized Granodiorite Porphyrite. This variety is represented by the acid schlieren in the dacite. The twin lamellae of plagioclase phenocrysts are slightly flexed. Segmentation of quartz and plagioclase has taken place owing to the increase in granularity of the groundmass. Sericitization of plagioclase is most marked in the rounded granodiorite porphyrite xenoliths of the dacite along the eastern part of the dacite-granite contact. The original granophyric texture of the groundmass is partially destroyed in the chilled base of the dacite and it is granular in the extreme recrystallized dacite types. With the change in granularity of the groundmass the original subhedral and embayed form of quartz is destroyed and lacinear borders are prominent around plagioclase. Biotite shows little change, except for slight flexing and an apparent decrease in the width of pleochroic haloes surrounding enclosed zircons. Hypersthene or its pseudomorphs are generally altered to a dark green biotite with precipitation of iron ore.

Schistose Granodiorite Porphyrite. The quartz-biotite-hypersthene dacite has metamorphosed the granodiorite porphyrite into fine and coarsely schistose porphyrite. Interlocking dark biotite flakes segregate and form discontinuous parallel bands between mosaics of quartz porphyroblasts. The microphenocrysts of plagioclase form segregations in the groundmas and quartz is recrystallized into mosaics, which are elongated parallel to the schistosity. Segmentation of the original phenocrysts by the groundmass is an additional feature of the coarse schistose porphyrite.

The schistose granodiorite porphyrite differs from the schistose hypersthene dacite at Warburton and Selby by the absence of hornblende. This suggests that temperature and pressure conditions were low at the time of the emplacement of the dacite at Violet Town.

Quartz-biotite-hypersthene Dacite

The most notable feature of this widespread flow is the abundance of gleaming black biotite flakes and coarse acid schlieren of granodiorite porphyrite (Plate V, fig. 1). The dacite has a very coarse texture when compared with that of normal lavas, weathers easily and is contaminated with small bedrock hornfels xenoliths. Acid schlieren in the chilled base are small and elongated. As is to be expected in such widespread flow, considerable variations are observed. Towards its base it is extremely altered and light green in colour. Hypersthene is rare in the altered variety and its content decreases in the recrystallized types towards the granite contact. The altered section of the dacite grades into its dark chilled base, where hypersthene, garnet and cordierite are in abundance.

Anhedral slightly embayed quartz, zoned plagioclase (Ab_{54}-Ab_{60}), altered hypersthene, biotite, together with occasional corroded garnet and pinitized cordierite, are set in a highly potassic microgranular groundmass. Orthoclase is absent as phenocrysts but is abundant in the groundmass, especially in the recrystallized varieties of dacite.

Pleochroic hypersthene (X = pinkish red, Y = light yellow, Z = green) is rarely observed by itself; it either paramorphically alters to a plum-brown, slightly pleochroic anthophyllite or to biotite. All stages from the incipient alterations to the complete anthophyllite or biotite pseudomorphs can be observed. Metasomatic hypersthene also occurs as small enhedral grains in an outer rim surrounding an inner cordierite corona about garnet. Garnet and cordierite are the important accessories, and together with hypersthene form an interesting reaction trio, which will be discussed later. Cordierite is pinitized and rarely pseudomorphed by beam textured serpentine; sillimanite needles, dark green spinel octahedra, and dusty iron ore surrounded by pleochroic lemon-coloured haloes are seen in the cordierite core.

The grainsize of the groundmass ranges from fine microgranular, in which acid schlieren can be recognized (i.e. in the base of the flow) through all microgranular stages to a final coarsely recrystallized groundmass, which tends towards micro-granitic affinities. With increase in grainsize, the high potassic nature of the groundmass becomes more apparent, and lacinear borders are produced around quartz and plagioclase phenocrysts, as they appear to grow in size and enclose grains of the original microgranular groundmass around their borders; thus the original plagioclase develops a narrow rim of orthoclase. Owing to this increase in grainsize, quartz embayments lose their definition. Blue tourmaline, together with minor amounts of magnetite, zircon and apatite are present in the groundmass. Pennine occurs after anthophyllite or biotite in the more recrystallized dacites.

The altered portion of the dacite towards the base is characterized by sericitized plagioclase, quartz, chloritized biotite, corroded garnet, pinitized cordierite and extremely rare and corroded hypersthene. In the extreme cases of chloritization, sphene and epidote are relegated to the cleavage traces of biotite. Chloritization increases, biotite content decreases, hypersthene is practically absent, and sericitization is intensified and especially marked around included bedrock fragments in the lowest sections of the dacite. Also with increase in assimilation of rhyolite at the base the quartz-biotite-hypersthene dacite exhibits toscanite affinities. The chilled base of the dacite contains phenocrysts of quartz, plagioclase (Ab_7-Ab_6), biotite, altered hypersthene, conchoidal fractured garnet up to 1 mm. and occasionally pinitized cordierite up to 2 mm. set in a microcrystalline to hypohyaline groundmass, in which various viridites and opacites conform to the flow lines. Quartz and plagioclase are also present as small angular fragments in the groundmass. A characteristic feature of the groundmass is the sudden change from the usual microcrystalline to a radiolitic texture, producing a patchy effect over wide areas, the patches being usually drawn out in schlieren-like fashion. Their association with xenoblastic segmented plagioclase with flexed twin lamellae, similar to those in the granodiorite porphyrite schlieren, and their occasional micrographic texture, clearly point to their derivation.

The Strathbogie Granite

The Strathbogie Granite and Terip Terip Granite are parts of the same mass and the two rocks are identical. Baker (1940) described the Terip Terip Granite as a "potash rich, two mica cordierite granite" and in places it tends towards adamellite affinities. The Strathbogie Granite is coarse, porphyritic and easily weathered. The following additional features have been observed in the Strathbogie Granite as well as those recognized by Baker in Terip Terip Granite:

(i) The tendency for zoned oligoclase to become antiperthitic and possess a rim of orthoclase or albite. The potash intergrowths are present in small numbers and exhibit euhedral outlines.

(ii) The existence of a brownish-grey isotropic mineral, with refractive index less than that of cordierite, in association with the usual green micaceous products ("pinte") and rare serpentine after cordierite. It appears to be the initial alteration product of cordierite, which finally alters to the usual pinite aggregate.

(iii) The occasional micrographic nature of the microperthite. Myrmekitic bordered microperthite occurs along the Molesworth contact edge.

(iv) Rare biotite-orthoclase dactylitic intergrowths.

(v) Pink-red garnets up to 1½ cm. altered to green micaceous products and biotite.

The Strathbogie Granite becomes slightly less coarse-grained towards the contacts, especially along the contact with the dacite. Sedimentary xenoliths up to 10 inches are rare and represented by aggregates of biotite flakes.

The leuco-granites along the contact between the Strathbogie Granite and the dacite are fine-grained and porphyritic, and differ from the Strathbogie Granite in texture and biotite content. The leucocrates resemble granite porphyries and range from granite porphyry to granodiorite porphyrite. Crystals of cordierite with pinite are common. The felspar phenocrysts are similar to those in the main granite and the potash groundmass exhibits graphic tendencies.

Micro-pegmatitic Granite

As a result of metasomatism by the late stage instrusives, orthoclase, up to 3 cm., and quartz porphyroblasts, occasionally associated with muscovite, are set in a medium-grained groundmass of felspar and biotite. Veinlets of orthoclase containing an inner quartz vein traverse the metasomatized granite.

The obvious porphyritic nature of the hand specimen is not apparent in thin section. Orthoclase is in excess of albite-oligoclase, which is sericitized and surrounded by a rim of orthoclase. Orthoclase and quartz form micro-pegmatitic and micro-granophyric intergrowths. Myrmekitic plagioclase is rare. Pinitized cordierite, ranging from phenocrysts of 4 mm. to groundmass size, with sillimanite and quartz inclusions are abundant. Muscovite, biotite, secondary quartz and rare garnet comprise the remainder of the even grained granitic groundmass.

The nature and abundance of biotite, together with field evidence, suggests that this rock may have been derived from the quartz-biotite-hypersthene dacite; however, the plagioclase composition, and size and alteration of the cordierite, leave little doubt that the micro-pegmatitic granite must be related to the Strathbogie Granite.

Late Stage Instrusives

The biotite aplites which intrude the Strathbogie Granite are narrow, fine-grained, and contain no tourmaline nodules. The widespread aplites concentrated along the granite-dacite contact zone are coarse, wide, and frequently contain tourmaline nodules and cordierite. Microscopically, microperthite, albite-oligoclase, quartz and muscovite form a saccharoidal texture, in which potash felspar is slightly in excess of soda felspar. The aplites along the contact zone are intruded by small tourmaline-bearing pegmatitic veins, around which the potash felspar possesses micropegmatitic borders. Tourmaline is either interstitial to quartz, black needles filling small vughs or in nodules associated with quartz and felspar.

The quartz-tourmaline nodules are conspicuous against the white aplitic background and, owing to their resistance to weathering agents, they project above the host in a wart-like fashion. The nodules are elliptical and in the fine-grained biotite aplites they tend to possess a cream felspar halo. They vary from ½ inch to 3 inches in diameter and their border with the host is irregular and abrupt. Quartz and altered felspar are present throughout the nodule, quartz being in excess owing to the replacement of the orthoclase by tourmaline. The tourmaline is the schorlite variety. It favours replacement of cloudy microperthite with the liberation of quartz. Albite-oligoclase is more resistant to tourmalinization and is generally altered to an aggregate of kaolin, chlorite, muscovite (rare), quartz and analcite. Tourmaline in the outer regions of the nodules is interstitial to quartz and felspar, with anhedral topaz often associated with it. Similar nodules have been described by Edwards (1936) from the granite of Clear Creek, near Everton.

The main biotite-tourmaline-cordierite aplite separating the Violet Town Volcanics from the Strathbogie Granite grades towards its centre into a leucoadamellite porphyry, whose porphyritic texture is more marked and distinct from that of the leuco-granite border facies. The adamellite porphyry contains phenocrysts of euhedral perthite, an inch in size, and subhedral albite-oligoclase of about half an inch, together with microphenocrysts of quartz, cordierite and biotite, set in an even medium saccharoidal textured groundmass of the same minerals. The felspar phenocrysts exhibit sericitized and myrmekitic characteristics and a high soda content of the perthite phenocrysts is indicated by the optical properties determined on their fragments.

The Barjarg Granite

The normal rock possesses a dark orange colour owing to the predominance of felspar. Where intensely sheared the granite is green because of the strong development of biotite. Orange-coloured felspar and quartz form the main part of the coarse-textured granite with interstitial dark green biotite, muscovite and dark cordierite pseudomorphs comprising the remaining accessories.

Microscopically, the felspars are albite-oligoclase and microperthite, with numerous inclusions of dusty iron ore, which contributes to their colour. The twin lamellae are flexed and anhedral quartz exhibits undulatory extinction in the sheared granite. Quartz and felspar contain stringers of orthoclase. The microperthite intergrowths tend to become microcline-microperthite as very fine lamellar twinning is observed in the potash section of the intergrowth. In this respect it is interesting to note that Chayes (1952) has recently noticed the marked tendency for perthitic microcline to be associated with highly undulant or granulated quartz. Albitization is also a feature of the Barjarg Granite, which is probably an end member of the Strathbogie Granite. The pseudomorphs after cordierite are serpentine and muscovite. Summers (1908) described this granite without any mention of the sheared specimens and the occurrence of cordierite.

Metamorphic Rocks

The formation of quartz-muscovite hornfels is the first sight of contact metamorphism in Silurian impure sandstones or mudstones. With increase in grade, reddish-brown biotite is formed and later accompanied by cordierite which is developed in place of andalusite owing to the relatively high iron and magnesium content of the original sediment. Cordierite is turbid in the high grade hornfels, as well as altered in small amount to pinite, and contains pools of quartz. A narrow spotted zone of grey-green cordierite can be observed in polished specimens of the granite-hornfels contact in the south. Also in the same specimen the original cross-bedding of the sediments is preserved and ptygmatic-like folds are formed to within an inch of the granite contact edge (Plate V, fig. 3).

The hybrid hornfelsen on Mt. Sugarloaf resemble quartz-porphyries, but under the microscope they are confirmed to be hornfels made up of quartz segregations, numerous small biotite flakes either in clots or diffused in the groundmass, sheared orthoclase and plagioclase crystalloblasts. Orthoclase, plagioclase or biotite are in excess, depending upon the degree of admixture of rhyolite, dacite and sediment respectively.

The contact breccia consists of rounded rhyolite xenoliths up to 4 cm. and numerous angular bedrock hornfelsic xenoliths set in a confused rhyodacitic matrix (Plate V, fig. 2). In addition the contact breccia at Mt. Sugarloaf contains abundant granodiorite porphyrite schlieren. The original bedding of the sediments can still be recognized, and biotite either alone or with garnet is developed in the rhyolite xenoliths owing to assimilation by the dacite. The felspars of the breccia are either orthoclase derived from the rhyolite or kaolinized and sericitized plagioclase from the dacite host. Clear anhedral quartz is conspicuous in the strew of the breccia, being mainly derived from quartz phenocrysts of the rhyolite.

Limburgite

Edwards (1938) classified this flow and gave its chemical analysis. Hills (1938) discussed its age and petrography.

Tinguaite(?) Dyke

The dyke is a foot wide and is extremely weathered, ranging from a grey-blue colour, through brown to a white clayey substance. In all stages small white felspar laths can be seen.

In thin section, what was probably nepheline in euhedral crystals up to 2 mm., and laths of felspar, now completely altered, lie in a tinguaitic groundmass of numerous iron ore needles and nepheline(?). The alteration products after nepheline are of weak birefringence and probably zeolites, occasionally accompanied by a pale-coloured mineral exhibiting good cleavage and first order yellow interference colours, presumably cancrinite. The iron ore is probably the result of extreme alteration of the original pyroxene, probably aegirine.

Mineralogy

Hypersthene and Its Alterations (Plate IV, figs. 1 and 2)

The hypersthene content fluctuates in the quartz-biotite-hypersthene dacite but it is the characteristic constituent. Hypersthene occurs as a primary mineral of crystallization and also as a constituent of coronas about garnet. The pleochroism of the primary hypersthene (X = pinkish red, Y = light green, Z = green) varies in intensity, but it is usually in agreement with a relatively high iron content. This hypersthene reacts with orthoclase to form biotite, as in other Upper Devonian Dacites of Victoria and in a related porphyrite at Tooborac (Singleton, 1949). Summers (1923) recognized biotite and "rather rare examples of corroded hypersthene" in the Strathbogie Ranges, from which he suggested "that the temperature at which crystallization ceased had been sufficiently low for the reaction between the hypersthene and felspar to be almost complete." Edwards (1932) explained the hypersthene-biotite reaction from evidence obtained in the Black Spur Dacites. The hypersthene alteration trends in the Violet Town Dacite support the influence of his postulated "environment" factor in this reaction. Owing to rapid cooling and low potash content, hypersthene in the base of the dacite exhibits only a narrow rim of biotite (red brown or dark green); however, with slower cooling and increase in orthoclase content, deep biotite coronas are produced around hypersthene in the upper sections of the dacite.

Hypersthene also shows a marked tendency for a paramorphic alteration to anthophyllite in the quartz-biotite-hypersthene dacite. Edwards (1932) described a similar alteration in an anthophyllite-garnet rock in the Warburton granodiorite-dacite contact zone. The recognition of anthophyllite is based on purely optical data and although Rabbitt (1948) has shown by X-ray study that pseudo-orthorhombic properties can be obtained from amphibole asbestos specimens with an apparent parallel extinction, the more prismatic amphibole sections possess definite parallel extinction and they are assumed to conform with the properties of anthophyllite. Generally anthophyllite occurs outside the original brown biotite rim of the hypersthene and in turn it alters to a brown-green biotite, which grades into a green variety on the outer edges. Tattam (1924) noticed the adjustment in composition of the original red-brown biotite in accidental xenoliths of the Bulla Granodiorite. On chemical analyses (1929) he considered the somewhat greenish colouration in brown biotite occurring in certain quartz-mica-diorites and granites to be due to the high lime content. In this respect the alteration of anthophyllite to a green biotite is of some importance, as appreciable amounts of calcium are common in the aluminous anthophyllite molecule. However, Hall (1941) showed that the colour is very little indication of the composition of biotite. Anthophyllite is altered hydrothermally to antigorite (bastite) towards the granite contact. Edwards considered the alteration of hyersthene to anthophyllite due to special conditions of metamorphism at Warburton, in which pressure was an important factor. The Violet Town Dacite reveals signs of metamorphism by its recrystallized groundmass, but the anthophyllite pseudomorphs appear to be independent of metamorphism. Moreover, the occurrence of anthophyllite outside as well as in place of the original biotite rim about hypersthene suggests that it has formed by reaction of hypersthene with the groundmass constituents prior to consolidation. Although the normal alteration trend for hypersthene is to a green hornblende, alteration to anthophyllite was preferred in the Violet Town Dacite and its formation was caused by one or more of the following:

(i) Stresses operating during the final stages of crystallization.
(ii) Change from dry to wet conditions.
(iii) A deficiency in calcium and an excess of alumina in the magma.

The co-existence of pyrogenetic garnet and cordierite (anti-stress minerals) in the dacite raises doubt as to the value of pressure control in the formation of anthophyllite (stress mineral). Moreover, from the decomposition products of garnet and cordierite, described later, it is deduced that reduced pressure and excess alumina and silica were the predominant factors in the final stages of crystallization of the residual magma. Evidently hypersthene can be stable under wet conditions (Wilson, 1952), so that the alteration of hypersthene to anthophyllite does not necessarily imply a change from dry to wet conditions. Although hydration must have been important in the change from hypersthene to amphibole, evidence supports the deficiency of calcium and excess alumina as the critical factor in the formation of the anthophyllite. Rabbitt (1948) has shown that the anthophyllite series is a three-component one of limited isomorphism involving chiefly Mg, Fe and Al. That calcium was deficient in the magma is revealed with comparison of the chemical analyses of the Violet Town Dacite (Summers, 1914) and the similar dacite at Black Spur (Edwards, 1932), where hypersthene readily decomposes to biotite. The fluctuations in the calcium, sodium and potassium contents between the Violet Town and Black Spur Dacites can be explained partly by the differences in composition of zoned plagioclases between the two similar dacites and partly by the calcium deficiency in the transformation of the hypersthene to anthophyllite instead of hornblende.

When the breakdown of hypersthene in the Violet Town Dacite is considered in the light of Edward's "environment" hypothesis, it is obvious that, although cooling conditions and abundance of potash were favourable for the complete replacement of hypersthene by biotite, chemical factors were not completely favourable for the formation of extensive biotite or hornblende. Hence it appears that hypersthene crystallizing slowly under conditions of low calcium, excess aluminium and hydroxyl ions, is rendered unstable and replaced by anthophyllite, in which more Fe Mg and Si atoms can be replaced by Al atoms.

Garnet Coronas and Associate Dactylites

Although not as abundant as cordierite or hypersthene, garnet is an important constituent of the quartz-biotite-hypersthene dacite, and to a lesser extent of the basal rhyolite and granitic rocks. Its presence is a common feature in the Victorian dacites and associated rhyolites of similar age. Almandine is the predominant molecule of the garnet (Edwards, 1936). Garnet occurs as small unaltered fragments in the chilled base of the dacite but elsewhere it is unstable and surrounded by an inner cordierite corona, containing small vermicular intergrowths, and an outer hypersthene rim. The garnets in the Strathbogie Granite are associated with assimilated sedimentary xenoliths and possess an irregular border; they are rimmed with sericitized and pinitized cordierite and, unlike the garnets in the dacite, the cordierite contains numerous inclusions of biotite, apatite and iron ore.

The cordierite rim in the dacite consists of numerous anhedral interlocking crystals (2V approx. 80°), is larger than the hypersthene rim, and increases in size as garnet is resorbed. Unlike the presumed primary cordierite of the dacite, it is practically unaltered, probably owing to its protective hypersthene rim or the dry conditions of formation. Hypersthene granules comprise the incipient outer rim, which in comparison with the cordierite rim exhibits little change in width. Cordierite forms a continuous rim about garnet, whereas hypersthene is discontinuous and generally the hypersthene anhedra are absent or decrease in number where felspar or biotite are in contact with the cordierite rim. As resorption of garnet is completed, hypersthene loses its identity by dispersion in the groundmass or alteration to biotite. In general the inner cordierite rim increases inwards at the expense of the garnet and hypersthene towards the groundmass.

Dactylites in the cordierite project radially from the garnet to within a short distance of the outer hypersthene rim and owing to their minute thickness they are colourless. Their composition is difficult to assess; the rarer, thicker and more rounded types usually included in the slender and transparent dactylites are hypersthene, and on the assumption that there has been no loss of material in the whole garnet structure, the clear dactylites which show variation in extinction angle must also be a ferromagnesian silicate. Moreover, from consideration of the garnet analysis (Edwards, 1936) it can be assumed that the hypersthene both in the outer rim and dactylites contains a considerable proportion of the iron originally present in the garnet. The dactylites and the outer hypersthene rim are closely related as only on rare occasions is hypersthene present without the dactylites.

Towards the base of the dacite the garnet coronas and associated dactylites are rare and altered. Cordierite is altered to a sericite aggregate, the dactylites to a green biotite, and the outer hypersthene is either absent or replaced by biotite. The alteration of the dactylites to biotite also suggests that the dactylites were originally a pyroxene.

Besides the above occurrence, altered cordierite and brown biotite surround garnet. This cordierite resembles the presumed pyrogenetic cordierite in the rest of the dacite and garnet appears stable, since it does not possess the usual sieve border structure of unstable garnets. This may represent the formation of garnet accompanied by a little muscovite by the action of cordierite and biotite, for which Tattam (1925) provides a probable equation.

Another important and restricted occurrence of garnet is when it is surrounded on one side by a felspar corona and on the other by cordierite with associated dactylites and outer hypersthene rim, i.e. the one garnet exhibits stable and unstable characteristics (Plate IV, fig. 4). Garnet and felspar are idiomorphic along the contact with each other and the felspar is either a single twinned crystal or several euhedra of the same composition as plagioclase phenocrysts in the remainder of the dacite. Edwards (1936) regarded rims of idiomorphic felspar containing zircon and epidote(?) grains identical with those enclosed in embayed garnet as representing "reject matter" in the growth of garnet, and in other cases contemporaneous crystallization of felspar and garnet was evident. In the Violet Town Dacite, felspar does not appear to be "reject matter" and it may have formed by reaction between previously crystallized garnet and the residual liquid. However, owing to their idiomorphism, a greater possibility is that the garnet and felspar crystallized from the magma almost contemporaneously, with garnet slightly preceding felspar, which shielded it from the remaining constituents of the magma.

In a gneiss from the Mogok region of Burma, J. A. Dunn (1932) described similar garnet-cordierite-hypersthene structures which were thought to represent products of solid diffusion without participation of a solution phase. He suggested that already existing cordierite was essential to the process and that vermicular intergrowths in the cordierite corona were evidence of the mechanics of silica transfer. However, the dactylites associated with the garnets of the Violet Town Dacite are not true intergrowths and cordierite is secondary after garnet. Hence despite their similarity, it is apparent that the nature of formation was different.

Any theories advanced to explain the garnet coronas and associated dactylites must consider the following:

(i) The garnets are immersed in an extremely recrystallized groundmass of high potash and silica content.

(ii) The garnets are unstable in contact with the groundmass but stable against plagioclase felspar.

(iii) The difficulty in distinguishing between the results of solid and pore solution diffusion.

It is assumed that garnet crystallized from magma which had assimilated alumina, under conditions of high pressure. On extrusion of the still differentiating and contaminated magma, garnet became unstable in an environment of low pressure and increasing silica content, whereby it was replaced by a mineral with a smaller ferromagnesian to silica ratio (cordierite). The dactylites and outer hypersthene rim may have formed under slow conditions of cooling in the abundance of mineralizers, but still a greater possibility is their formation as a result of metamorphism by later granitic intrusions. In both environments the dactylites represent solution channels through which migration (diffusion) of material took place and the hypersthene granules are the residue from the breakdown of garnet to cordierite. Material (hypersthene?) in some of the clear dactylites is evidently where obstruction of the migrating solutions took place.

If the stability of garnet is determined by the excess of silica (beyond the requirements of the crystallizing ferromagnesians and felspars) rather than a pressure reduction, then in order to establish chemical equilibrium the number of outward migrating Fe and Mg ions in the garnet structure would be balanced by an equal number of inward migrating silica ions. This theory would explain the directions in which the cordierite and hypersthene rims increase their width. On the metamorphic theory the kinetic energy of the Fe and Mg ions in the garnet structure is increased by the elevated temperature and this energy may exceed the migration energy for these ions, thus liberating Fe and Mg ions from their co-ordination and allowing them to migrate to other structures, cordierite and hypersthene. In this respect the dactylites represent the transfer of Fe and Mg ions from a dispersed phase to a solid structure.

The close association of dactylites with any one cordierite crystal in the inner rim suggests that the dactylites may represent the exsolved portions of an unknown solid solution. However, their radial projection from the garnet borders suggests relationships with the outer hypersthene rim and the migration theory is thus preferred.

Hence it appears that pyrogenetic garnet is rendered unstable when pressure decreases and silica content increases, and where plagioclase "shields" are absent it breaks down to cordierite. Later metamorphism of the dacite by granitic intrusions enable Fe and Mg ions liberated from the unstable garnet structure to migrate to regions of lower chemical activity, where dactylites and an outer hypersthene rim are formed. From this aspect the two-ply coronas after garnet in the Violet Town Dacite are not strictly synantectic products, and moreover they illustrate the importance of the geological environment in their formation. The amounts of secondary (metasomatic) hypersthene and cordierite formed in the dacite from the breakdown of garnet is subordinate compared with the pyrogenetic hypersthene and cordierite, and that the formation of much hypersthene-cordierite bearing calc-alkali rock by this process is extremely doubtful.

The garnet-cordierite and hypersthene-anthophyllite-biotite trends are both responses to the increasing alumina and silica content of the magma.

Cordierite and Its Alterations

Cordierite is present in all members of the Strathbogie Igneous Complex. Its presence in the Violet Town Volcanics is significant, since it is an important constituent of the acid members of the Victorian Upper Devonian lavas. Its mode of occurrence and alteration products in the various members are listed below.

Baker (1940) described cordierite from Terip Terip Granite and recognized it in the related Strathbogie Granite. Cordierite's alteration products have received

Member of the Complex	*Mode of Occurrence*	*Alteration Products*
1. Rhyolite	Completely altered phenocrysts	Chlorite and serpentine
2. Granodiorite porphyrite	Subhedral phenocrysts	Pinite and associated yellow isotropic product
3. Quartz-biotite-hypersthene dacite	Anhedral phenocrysts, some embayed with orthoclase or as a garnet reaction rim	Yellow isotropic product; spinel and sillimanite; rare pinite, serpentine and sericite
4. The granites, aplites and leucocrates	Subhedral phenocrysts	Pinite with rare isotropic product.
5. Quartz-biotite-cordierite hornfels	Xenocrysts	Turbid product, biotite and pinite.

a great deal of attention in the past, especially by Tattam (1925 and 1929) and later by Baker, who mentions that "part of the pale greenish-yellow coloured products . . . . is isotropic". Hills (1932) also mentions an "almost isotropic green chlorite" in pinite pseudomorphs. This material appears to represent the initial alteration of cordierite prior to pinitization and thus predominates in the dacite, as quicker cooling of the lavas prevented complete alteration of cordierite. Slower cooling and an increase in potash and water content favoured a more complete alteration (i.e. pinitization) in the granitic rocks. The isotropic product varies in colour, mainly in various shades of yellow and a turbid grey-brown, and possesses a refractive index less than that of cordierite.

The exothermic decomposition of cordierite is regarded as occurring late in the crystallization period, where alkaline bearing solutions are abundant. In this respect the rarity of micas after cordierite in the dacite is puzzling in view of the high potash content of the groundmass in which cordierite is immersed. Shielding effects of minerals, rapid solidification of the magma, or dry conditions of formation may contribute to this fact.

The precipitation of sillimanite and spinel in the core of some cordierite phenocrysts in the dacite is probably evidence of solid diffusion or reaction through the medium of aqueous pore solutions which were initiated by a local deficiency in silica. Tattam (1924) has noticed this cordierite alteration where liberated quartz has been apparently melted off, and in a more complex case Dunn (1932) favours solid diffusion of garnet molecules through cordierite where they react with sillimanite to form spinel-cordierite intergrowths.

The presence of cordierite in the Victorian igneous rocks is regarded as indicative of a contaminated magma (Tattam 1925, and Baker 1940). The widespread occurrence of cordierite phenocrysts in the Violet Town Volcanics suggests crystallization from a magma greatly enriched in alumina, owing to assimilation of argillaceous sediments. The apparent restriction of cordierite to marginal granite facies suggests derivation from cordierite hornfels in the wall rock.

Petrogenesis

The petrogenesis of the Upper Devonian granodiorite-dacite suite of Victoria was first suggested by Edwards (1935) as an example of differentiation of Kennedy's primary tholeiitic magma type. In more detail, Edwards (1937) provided evidence for a bigeneric process, in which assimilation of "preheated and possibly fused granitic and alumina-rich sedimentary layers" and fractionation or differentiation of the basaltic magma were responsible for the formation of the various members (rhyolite to quartz diorite) of the calc-alkaline provinces. A modification of this theory is necessary according to recent evidence supplied by Hills (1952). The sequence (rhyolite, granodiorite porphyrite, dacite, granite and aplites) of the Strathbogie Igneous Complex agrees with any theories of differentiation.

In order to explain the slightly greater silica content in the older dacite when compared with the younger granite, Summers (1922) maintained that prior to its extrusion differentiation was more advanced in the volcanic phase and that subsequent differentiation and solidification of the granite took place in a shorter period. The basal rhyolite is evidently the earliest differentiate which was "tapped" prior to roof foundering and consequent large-scale assimilation, initiated by the close approach to the surface of the granodiorite-porphyrite. Moreover, the similarity between the composition of the granodiorite-porphyrite and the quartz-biotite-hypersthene dacite, and the presence of unstable hypersthene in the granodiorite-porphyrite, support the fact that the emplacement of the bulk of the magma, in the form of the dacite, must have followed immediately after the intrusion of the granodiorite-porphyrite, as hypersthene had already commenced to crystallize in the granodiorite-porphyrite.

The widespread and uniform occurrence of hypersthene, garnet and cordierite in the Violet Town volcanic province provides evidence for assimilation of large quantities of alumina and suggests thorough mixing of very large masses of contaminated magma. That such assimilation had commenced in the early stages of differentiation is apparent by the occurrence of occasional pyrogenetic garnet in the rhyolite. In the light of this theory, the Strathbogie Igneous Complex represents a more advanced stage in the differentiation and crystallization history of the basaltic magma than is represented in other Victorian dacite-granodiorite provinces. Because of the slow approach of the basaltic magma towards the surface, crystallization and differentiation had been active for some time. The effect of slow crystallization (intratelluric) upon the early formed minerals in an environment of reduced pressure, increased alumina, potash and silica content is revealed in their pseudomorphs and corona structures. The silicate structure of the ferromagnesians readjust themselves to these conditions. The single chain metasilicate hypersthene is replaced by the double chain metasilicate anthophyllite, and garnet is replaced by cordierite, the degree of such replacement depending upon the rate of cooling and on the degree of metamorphism, which later modifies the original cordierite corona. Chilling at the base of the dacite has prevented any reaction of early formed hypersthene and garnet with the residual magma.

Structure

The structure of the complex is based upon the following observations:

(i) The recognition of rhyolite in its various structural environments in the Violet Town volcanic province, assuming that all these structural indicators belong to the one basal flow.

(ii) The existence of the original sedimentary platform as sedimentary inliers and numerous pebbles along the contact zone between the Violet Town Dacite and the Strathbogie Granite.

(iii) The concentration of late stage granitic intrusions in the granite-dacite contact zone. The intrusions occur either alone or with the inliers, in which case they lie on the granite side of the inliers.

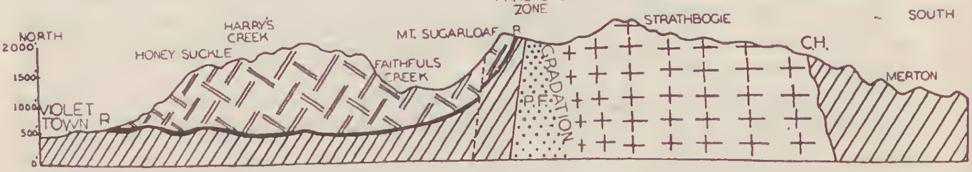

Fig. 3.—North-south sketch-section of the Strathbogie Igneous Complex. Legend and symbols as in Fig. 1. N.B.: For simplicity the granodiorite porphyrite in the depression at the foot of Mt. Sugarloaf is omitted and the Q-B-H-dacite is shown as an extrusive, which is not strictly correct (see text).

(iv) The large depression in the vicinity of the granodiorite porphyrite in the volcanic province.

The rhyolite outcrops with a low southerly dip in a limited area in the north, but it is mainly represented by xenoliths in the base of the dacite along the northern edge of the province and intermittently along the western and eastern edges. Rhyolite reappears at Mt. Sugarloaf as a sheared rock resting against sedimentary inliers with a steep northerly dip. Elsewhere along the granite contact rhyolite occurs as microcataclastic xenoliths in the recrystallized dacite. It is apparent that the rhyolite is continuous at the base of the quartz-biotite-hypersthene dacite and that it represents an assymmetrical syncline or basin with its steep limb in the south either against sedimentary inliers or granitic intrusions. The attitude of the rhyolite reflects the attitude of the bedrock formed probably in the following manner:

(i) Extrusion and solidification of rhyolite on an uneven sedimentary terrain.

(ii) Shallow intrusion of granodiorite porphyrite reaching the surface at a few places.

(iii) Owing to the proximity of the granodiorite porphyrite to the surface, the roof foundered and a general subsidence of large blocks was produced, especially along the southern edge, where drag along this main fracture sheared the rhyolite and caused it to dip steeply.

The depression in the vicinity of the granodiorite porphyrite and the steep dip of the rhyolite on Mt. Sugarloaf suggests that this region marks the position of major roof collapse. The actual mechanism of the granodiorite porphyrite intrusion is difficult to ascertain. Stoping is not apparent as bedrock xenoliths are absent and the porphyrite has been metamorphosed by the dacite. It is probable that the granodiorite porphyrite represents the approach of a differentiating magma to the surface and that it found its way to the surface through a subsidiary fracture, which was later on accompanied by further fracturing and roof foundering on a larger scale. In this manner the bulk of the magma was extruded as the widespread quartz-biotite-hypersthene dacite on to the subsided rhyolite basement. The abundance of granodiorite porphyrite schlieren throughout the dacite suggests that the porphyrite and the dacite were emplaced through a common channel. Also, the increase in hornfelsic xenoliths towards the sedimentary inliers and to a lesser extent towards the bedrock suggests that, after the major roof collapse, magmatic stoping was important. Although Summers (1922) believed that the yet undiscovered existence of the Palaeozoic platform between the dacite and granodiorite at Macedon was sufficient and conclusive evidence for overhead or magmatic stoping, its presence in the contact zone at Strathbogie has more significance. The platform remnants are evidence of roof collapse along annular fractures and that stoping was of only secondary importance, consequent upon the development of such fractures and roof foundering. Some stoping would be expected along these fractures as they are planes of weakness. Moreover, the annular shape of the granite-dacite contact and the approximate circular pattern of the Violet Town volcanic province is highly suggestive of subsidence of crustal segments on annular fractures. Although the dacite shows intrusive characteristics along the fracture contact zone with the granite in the south, and the outlying patches of dacite to the north of the main volcanic province may represent another 'intrusive edge', evidence along the western and eastern edges is insufficient to postulate the formation of a ring fracture in the emplacement of the Violet Town Volcanics.

The intrusive and extrusive characteristics of the dacite, its widespread distribution and the gradational tendencies between members throughout the province are features expected in large-scale roof foundering. Reduced pressure conditions in the magma chamber would favour the development of fractures in the roof. That such conditions prevailed at the time of the emplacement of the quartz-biotite-hypersthene dacite is evident by the breakdown of garnet to cordierite in the dacite.

The area of late stage granitic intrusives on the southern side of the sedimentary inliers supports the hypothesis that the contact between the Violet Town Volcanics and the Strathbogie Granite represents a line of weakness in the original surface structure, along which large-scale movement has taken place. The late stage granitic intrusions preferred intrusion along this fault zone rather than their usual forceful injection into the previously consolidated granite.

The homogeneous nature of the Strathbogie Granite over a wide area (approximately 430 square miles), except for occasional large tourmaline aplites, the absence of sedimentary xenoliths and restriction of cordierite-bearing granite to the periphery of the intrusion suggest that magmatic stoping played only a minor role in its emplacement. The circular pattern of the southern and western boundaries of the Terip Terip Granite, which is continuous with the Strathbogie Granite, and the occurrence of annular "embayments" of Silurian sediments along this edge suggest emplacement by the mechanism of cauldron subsidence. Since the northern boundary of the Strathbogie Granite is bounded by a pre-granite fault, the cauldron subsidence theory would be strongly supported if a similar fault could be proved along the southern boundary of the granite where the trend is linear and approximately parallels the northern boundary.

Age and Comparison with Similar Provinces

David (1950) considered plutonic intrusions, which are preceded by comagmatic hypersthene-bearing porphyries and porphyrites and which have introduced little or no important ores, as late Middle Devonian in age. Moreover, from evidence supplied by Summers (1908 and 1914), David cited the Strathbogie Igneous Complex and the related Tolmie Igneous Complex as typical examples of such intrusion. Again, he mentions the striking similarity "in character and environment" between the Marulan composite bathylith in the Goulburn district, N.S.W. (Woolnough, 1909) and the Strathbogie Complex, apparently including the Tolmie Complex as well. However, there are no known Middle Devonian intrusions in Victoria, and their Upper Devonian age is based on definite fossil evidence in combination with petrological and physiographical relationships (Hills, 1929 and 1931). From this point of view, the remarkable similarity between the quartz-biotite-hypersthene rhyodacite in the Cerberean Ranges, the quartz-biotite-hypersthene dacite in the Black Spur area and in the Violet Town Volcanics, where no interbedded fossiliferous sediments are present, must be evidence in favour of an Upper Devonian age for the Strathbogie Igneous Complex.

The Tolmie Complex has been shown to be pre-Lower Carboniferous and it has been linked petrologically with the post-Silurian Violet Town Volcanics. There are considerably more flows in the Tolmie province and, although they include some dacites, the flows tend to be more alkalic. The numerical and chemical differences between the members of the two complexes may indicate structural variations, which in turn would reflect their mode of emplacement rather than being evidence for differences in age, as from the above discussions the two

CORRELATION TABLE OF VICTORIAN UPPER DEVONIAN GRANODIORITE-DACITE SUITES

		Cerberean Ranges (Thomas, 1947)	*Black Spur* (Edwards, 1932)	*Mt. Dandenong* (Morris, 1913)	*Macedon* (Skeats and Summers, 1912)	*Strathbogie Igneous Complex*
EPI-UPPER DEVONIAN SERIES		Acid Ring Dykes (Granodiorite Porphyrite)	Granodiorite	Granodiorite	Granodiorite	Granite
UPPER DEVONIAN SERIES	Upper Acid Group (3,000 ft.)	Quartz-biotite-hypersthene Rhyodacite Nevadite-Toscanite Nevadite	Hypersthene Dacite Quartz-biotite-hypersthene Dacite Quartz Dacite	Hypersthene Dacite Middle Dacite Lower Dacite	Hypersthene Dacite	Quartz-biotite-hypersthene Dacite (?) Granodiorite Porphyrite Rhyolite
	Middle Acid Group (500 ft.)	Fragmental Toscanites Dark Rhyolite		Upper Toscanites Lower Toscanites		
	Basic Group (550 ft.)	Basalts with Pyroclastics Sediments and Ash Beds				
	Lower Acid Group (950 ft.)	Tuffs Rhyodacite Rhyolite				
		Basal Conglomerate			Basal Conglomerate	

complexes must be very closely related and must belong to the same period of igneous activity.

A correlation table has been compiled of well-known Upper Devonian granodiorite-dacite suites on the basis of the detailed sequence of the Cerberean Ranges (Thomas, 1947). Although related to the Upper Devonian igneous activity, the South Blue Range Group, the Tolmie Igneous Complex, the Mt. Wellington and Jemba Rhyolites are not considered in the tabulated sequence. Hypersthene-bearing dacites and comagmatic plutonic intrusions are rare or absent in the related occurrences, and in general they are more alkalic. Hence it may be either that evidence is forthcoming for a calcic and a potassic magma with different ages (Melbourne Handbook 1935), or that the apparent contrast in chemical composition indicates the different modes of extrusion from a common magma.

The granodiorite porphyrite is definitely pre-quartz-biotite-hypersthene dacite and although a granodiorite porphyrite is related to a similar dacite at Black Spur, the two porphyrites have little in common. The granodiorite porphyrite in the Strathbogie Complex and the hypersthene porphyrite at Tooborac (Singleton, 1949) are similar in that they contain hypersthene and are pre-granite. Ring dykes of granodiorite porphyrite are common around the northern edge of the Cerberean Ranges, where according to Hills (Thomas, 1947) this dyke is younger than the Upper Devonian lavas and represents the main channel through which the lavas were extruded. The granodiorite porphyrite has also an important structural significance in the Violet Town Volcanics, but not in the same manner as the porphyrite in the Cerberean Ranges.

The Strathbogie Igneous Complex reveals the following important features in comparison with other Victorian granodiorite-dacite provinces:

Similarities	*Dissimilarities*
(i) The dacite has a highly potassic groundmass which is more apparent in the recrystallized types.	(i) The absence of pyroclastics, fragmental toscanites and basic members.
(ii) Hypersthene, garnet and cordierite are common in the acid members.	(ii) The fewer dacite and porphyry flows.
(iii) Rhyolite is usually at the base of a group or formation.	(iii) The presence of a structural weakness (fracture) between the volcanic and the plutonic provinces.
(iv) The province possesses calc-alkaline affinities.	(iv) The presence of a granodiorite porphyrite older than the dacite.
	(v) The coarse texture of all members.
	(vi) The minute thickness of the rhyolite.

The overall significance of the diversities reflects variations in the emplacement mechanism rather than affording evidence for any variation in age between the Victorian granodiorite-dacite provinces.

Edwards (1932) assumed that the difference in intensity of metamorphism between Victorian granodiorite-dacite contacts was a function of the degree of 'de-roofing' or depth of erosion in the contact zone. It is evident from the study of the Strathbogie granite-dacite contact that the mode of intrusion is an important factor besides temperature and thickness of the dacite penetrated by the granite.

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Bibliography

Baker, G., 1940. Cordierite granite from Terip Terip, Victoria. *Am. Miner.*, 25: 543-548.

Brammall, A., and H. F. Harwood, 1932. The Dartmoor granites: Their generic relationships. *Q.J.G.S.*, lxxxviii, 2, 350, pp. 171-237.

Chayes, F., 1952. Association of Perthitic Microcline with undulant or granulated quartz. *Am. Jour. Sc.*, 250, 4: 281-295.

David, T. W. E., 1950. *The Geology of the Commonwealth of Australia*, Vol. I.

Dunn, J. A., 1932. Reaction minerals in a garnet-cordierite gneiss from Mogok. *Rec. Geol. Surv. India*, 65, 4: 445-456.

Edwards, A. B., 1932. The geology and petrology of the Black Spur area (Healesville). *Proc. Roy. Soc. Vic.*, 44: 49-76.

———, 1932 (a). The geology and petrology of the Warburton Area, Victoria. *Ibid.*, 44: 163-199.

———, 1932 (b). On the Dacite-Granodiorite contact relations in the Warburton Area. *Ibid.*, 44: 182-199.

———, 1935. Three Olivine Basalt-Trachyte provinces and some theories of petrogenesis. *Ibid.*, 48: 13-26.

———, 1936. On the occurrence of quartz-tourmaline nodules in the granite of Clear Creek near Everton. *Ibid.*, 49: 11-16.

———, 1936 (a). On the occurrence of almandine garnets in some Devonian igneous rocks of Victoria. *Ibid.*, 49: 40-50.

———, 1937. Quartz-diorite magma in eastern Victoria. *Ibid.*, 50: 97-109.

———, 1939. Petrology of the Tertiary Older Volcanic rocks of Victoria. *Ibid.*, 51: 73-98.

Fenner, G., 1914. The physiography of the Mansfield District. *Ibid.*, 26: 386-402.

Folinsbee, R. E., 1914. The chemical composition of garnet associated with cordierite. *Am. Miner.*, 26: 50-53.

Gregory, J. W., 1903. *The Geography of Victoria.*

Hall, Jean A., 1941. The relationship between colour and chemical composition in the biotites. *Am. Miner.*, 26: 29-33.

Hills, E. S., 1928. The geology and palaeontology of the Cathedral Range and the Blue Hills, in north-western Gippsland. *Proc. Roy. Soc. Vic.*, 41: 176-201.

———, 1929. Note on the evidence of the age of the dacites and associated igneous rocks in the Marysville-Taggerty district. *Ibid.*, 42: 36-40.

———, 1931. The Upper Devonian Fishes of Victoria, Australia, and their bearing on the Stratigraphy of the State. *Geol. Mag.*, 68: 803: 206-231.

———, 1932. The geology of Marysville, Victoria. *Ibid.*, 69, 814: 145-166.

———, 1933. An unusual occurrence of myrmekite, and its significance. *Ibid.*, 70: 829: 294-301.

———, 1934. Some fundamental concepts in Victorian physiography. *Proc. Roy. Soc. Vic.*, 47: 158-174.

———, 1938. The age and physiographic relationships of the Cainozoic Volcanic rocks of Victoria. *Ibid.*, 51: 112-139.

———, 1952. The Wood's Point dyke swarm, Victoria. *Sir D. Mawson Anniversary Volume.*

Rabbitt, J. C., 1948. A new study of the anthophyllite series. *Am. Miner.*, 33: 263-323.

Ramberg, H., 1952. Chemical bonds and the distribution of cations in silicates. *Jour. Geol.*, 60: 331-335.

Rankama, K., and Th. G. Sahama. *Geochemistry*. Univ. of Chicago Press, 1950.

Singleton, O. P., 1949. The geology and petrology of the Tooborac District, Victoria. *Proc. Roy. Soc. Vic.*, 61: 134-138.

Skeats, E. W., 1909. The volcanic rocks of Victoria. Presidential address A.A.A.S.

Skeats, E. W., and Summers, H. S., 1912. The geology and petrology of the Macedon District. *Bull. Geol. Surv. Vic.*, No. 24.

Skeats, E. W., 1928. The Devonian and older Palaeozoic rocks of the Tabberabbera District, North Gippsland, Victoria. *Proc. Roy. Soc. Vic.*, 41: 97-120.

SKEATS, E. W., 1935. *Outline of the Physiography and the Geology of Victoria.* A.N.Z.A.A.S. Handbook, Melbourne, 1935.

SUMMERS, H. S., 1908. Geology of the proposed Nillahcootie Water Conservation Area. *Proc. Roy. Soc. Vic.,* 21: 285-301.

———, 1914. On the origin and relationships of some Victorian igneous rocks. *Ibid.,* 26: 256-297.

———, 1923. The relationship between dacite and granodiorite in Victoria. *Ibid.,* 35: 134-138.

TATTAM, C. M., 1925. Contact metamorphism in the Bulla area and some factors in the differentiation of the granodiorite of Bulla, Victoria. *Ibid.,* 37: 230-247.

———, 1929. The metamorphic rocks of north-east Victoria. *Bull. Geol. Surv. Vic.,* 52: 1-61.

THOMAS, D. E., 1947. The geology of the Eildon Dam project. *Mem. Geol. Surv. Vic.,* No. 16.

TILLEY, C. E., 1939. Kyanite-gedrite paragenesis. *Geol. Mag.,* 76: 326-330.

WILSON, A. F., 1952. Occurrence of metasomatic hypersthene and its petrogenetic significance. *Am. Miner.,* 37: 633-636.

WOOLNOUGH, W. G., 1909. The general geology of Marulan and Tallong, N.S.W. *Proc. N.S.W., Lin. Soc.,* 34: 782-808.

The Geological Map of Victoria (16 miles to the inch), 1936. *Geol. Surv. Vic.*

Description of Plates

PLATE IV

Fig. 1.—Hypersthene (centre) partially replaced by anthophyllite, which is surrounded by a narrow rim of green-brown biotite in the quartz-biotite-hypersthene dacite. × 10.

Fig. 2.—Anthophyllite pseudomorph after hypersthene in Q-B-H dacite. Note apatite, zircon and iron ore inclusions of the original hypersthene maintained by the anthophyllite. Also a narrow rim of biotite surrounding anthophyllite. × 10.

Fig. 3.—Unstable garnet in Q-B-H dacite. The garnet is surrounded by a continuous inner rim of cordierite and dactylites and a narrow discontinuous outer rim of hypersthene granules (H). × 10.

Fig. 4.—Unstable garnets in Q-B-H dacite. The upper garnet (G) has been almost completely replaced by cordierite, dactylites and hypersthene (H). Half of the garnet at the bottom of the photograph is unstable and partially replaced by cordierite, etc., but the remainder is stable since it is "shielded" from the groundmass constituents by felspar (F). × 10.

PLATE V

Fig. 1.—Coarse acid schlieren (granodiorite porphyrite) in Q-B-H dacite. × $\frac{3}{4}$.

Fig. 2.—Contact breccia at base of Q-B-H dacite. Note rounded rhyolite xenoliths (white) containing garnet, and angular bedrock xenoliths (black). × 1.

Fig. 3.—Contact between the Strathbogie Granite and the Silurian sediments in the south of the complex. Note preservation of crossbedding in hornfels within one inch of the granite and a narrow band of cordierite (grey dots) hornfels nearest the granite. × $1\frac{1}{2}$.

Fig. 4.—Rhyolite (R) and granodiorite porphyrite (G) xenoliths in Q-B-H dacite along the eastern part of the fracture contact zone between the Violet Town Volcanics and the Strathbogie Granite. × $\frac{1}{2}$.

(Photographs: D. A. White.)